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Impact of different spacing and combination with organic manures on growth and yield attributes of strawberry (*Fragaria* × *ananassa*) cv. Jutoh special under mid-hill conditions of Uttarakhand

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Abstract
The present investigation entitled Effect of Spacing and Organic Manures on Strawberry (*Fragaria* × *ananassa* Duch.) cv. Jutogh Special under Mid-Hill Conditions of Uttarakhand was carried out at the Fruit Nursery, College of Horticulture, VCSG UUHF, Bharsar, Pauri Garhwal during the month of July 2018 to June 2019. The experiment was performed to find out the most suitable treatment combination for better yield and profitability to farmers. The experiment was laid out in a factorial Randomized Complete Block Design with nine treatments and three replications. The treatments comprise of different spacing with the combination of different Organic manures. Result obtained in present investigation showed that the plant spread, number of leaves per plant, leaf area, number of flowers per plant, duration of flowering, duration of fruiting, fruit set, yield per plant, yield per plot, TSS, Ascorbic acid, total sugar and antocyanin content were observed maximum with the treatment combination of S_2M_3 (30 cm × 30 cm) + Vermicompost (T_6).

Keywords: Strawberry, spacing, FYM, vermicompost, and cost benefit ratio

Introduction
Strawberry *(Fragaria* × *ananassa* Duch.) is one of the most popular soft fruit crops cultivated in temperate regions of the world for its fresh fruits. It is a member of family Rosaceae, with a chromosome number of 2n = 56 is a hybrid of genus *Fragaria.* Strawberry is an example of aggregate fruit. Strawberry keeps unique taste, flavour, and excellent source of vitamins, potassium, fibre and sugars. As compared to other berry fruits, strawberries contain a higher percentage of vitamin C, phenolics and flavonoids (Hakkinen and Torronen, 2000) [7]. The favourable soil pH range for strawberry is about 4.6-6.5 (Milosevic, 1997) [11].

Strawberry is the most important fruit plants for both fresh consumption and food processing in the temperate and subtropical areas. In North India, area under strawberry is increasing rapidly due to its remunerative prices. Annual world production of strawberry is increasing from 3 to more than 4 thousand MT. About 98% of the production occurs in the Northern Hemisphere, though production is expanding in the South (Hummer, 2009) [9]. In India it is commercially grown in Mahabaleshwar (Maharastra), Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand and low hills of Himanchal Pradesh.

Optimum plant spacing ensures proper growth and development of plant resulting in maximum yield of the crop and the best use of land. The system of planting, runners is usually planted along with the row at about 0.9 m apart and 0.45 m between the plants.

Organic manures like vermicompost, FYM, compost, bio fertilizers etc. have been utilized in agriculture as a significant source of organic manure. These manures helps not only in bridging the existing wide gap between the nutrient removal and supply but also in insuring balanced nutrient proportion, by enhancing response efficiency, and maximizing crop productivity of desired quality.

Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard and derive their nourishment from microorganisms that grow upon them. The process accelerates the rates of decomposition of the organic matter, alter the physical and chemical properties of the material, leading to a humification effect in which the unstable organic matter is fully oxidized and stabilized (Albanell *et al.*, 1988, Orozco *et al.*, 1996) [1, 14].

The fruit quality and yield of fruits can be increased by using the FYM and vermicompost which are helpful to reduce fruit drops and increase fruit yield and quality and improve the

physic – chemical properties of fruits and also increase the marketability as well as demand of fruits. Hence this investigation is done for better quality of fruits and increasing profitability.

Materials and Methods

The experiment was conducted at the Fruit Nursery, College of Horticulture, VCSG UUHF, and Bharsar during the month of July 2018 to June 2019. The soil of experimental site was sandy loam with a pH of 5.79. The experimental site received average rainfall of 120 mm (July 2018-June 2019) with average minimum and maximum temperature of 6.5 ^{0}C and 12.4 ^{0}C, respectively during the period of investigation. The experiment was laid out in factorial Randomized Complete Block Design with nine treatments replicated three. The nine treatments consist of (30cm×15cm) + No organic manure (T_1), (30cm×15cm) + FYM (T_2), (30cm×15cm) + Vermicompost (T_3), (30cm×30cm) + No organic manure (T_4), (30cm×30cm) + FYM(T_5), (30cm×30cm) + Vermicompost (T_6), (30cm×45cm) + No organic manure (T_7), (30cm×45cm) + FYM (T_8), (30cm×45cm) + Vermicompost (T_9). All the doses of organic manures with combination with inorganic fertilizer were applied at the time of planting and during flowering initiation and observations were recorded on plant spread, number of leaves per plant (cm), leaf area, number of flowers per plant, duration of flowering(days), duration of fruiting (days), fruit set(%), yield per plant(g), yield per plot(kg), TSS(ºB), Ascorbic acid (mg/100g), Total sugar(%) and anthocyanin content(mg/100g).

Result and Discussion

Growth Characters

Result on interaction effect of spacing and organic manures indicated that maximum plant spread (31.933 cm^2) was recorded under treatment combination S_2M_3 [(30 cm × 30cm) + Vermicompost] (T_6). While, the minimum plant spread (22.953 cm^2) was recorded in S_1M_1 [(30 cm × 15cm) + No organic manure] (T_1). Plant spread might be due to the production of more chlorophyll with inoculation of nitrogen fixers. It may also be due to the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological nitrogen fixation (Mohandas, 1987) [12]. The present results are in conformity of finding of Niyati *et al*., (2016) [13] in strawberry. Data clearly indicates that number of leaves per plant (25.803) and leaf area (41.707 cm^2) were recorded highest under treatment combination S_2M_3 [(30 cm × 30 cm) + Vermicompost]. Enhancement of growth might be attributed to the role of Vermicompost in greater the nutrient availability, and increase in beneficial enzymatic activities, increased population of beneficial microorganisms or the presence of biologically active plant growth influencing substances such as plant growth regulators or plant hormones in the vermicompost and humic acids (Arancon *et al.,* 2006) [3]. The application of vermicompost, because of the presence of humic acids (Chen and Aviad., 1990) [6]. These results were also in accordance with the finding of (Chaturvedi *et al.,* 2005) [5] in strawberry (Table 1.1-1.2).

Flowering and fruiting characters

The result on interaction effect of spacing and organic manures indicated that maximum number of flowers per plant (41.673), duration of fruiting (62.627 days) and fruit set (87.373 %) were recorded under treatment combination [(30 cm × 30 cm) + Vermicompost] S_2M_3 (T_6). The results are with accordance to the finding of Herencia *et al.*, (2011) [8] reported that composts contained nitrogen and phosphorus which enhanced vegetative growth and flower bud initiation. Arancon *et al.,* (2003) [4] reported that vermicompost applications enhanced flowering and fruiting in strawberry because Vermicompost enhance soil properties as cation exchange capacity and nutrient availability. The optimum level of nutrients as N, P and K and hormones provided by vermicomposts played a significant role in increasing Gibberellic acid in roots thus breaking bud dormancy and increasing flowering buds (Tagliavini *et al*., 2005) [17]. (Arancon *et al.,* 2003) [4] reported that Vermicompost applications enhanced flowering and fruiting in strawberry (Table 1.2-1.4).

Yield Parameters

The results from the (table 1.5) on interaction effect of spacing and organic manures indicated that maximum yield per plant (444.293 g) and (5.330 kg) were recorded under treatment combination [(30 cm × 30 cm) + Vermicompost] S_2M_3 (T_6). It was observed that the yield of fruits per unit area was inversely related to the plant spacing *i.e.*, the closer plant spacing produced the higher yield of fruits per plot and per hectare. Similar kind of findings was reported by Ughade and Mahadkar (2015) [19] and Shukla *et al.,* (2013) [15]. Thus higher yield of fruits was mainly contributed by the higher plant population per unit area in closer spacing. The result of the experiment found similarity with the findings of Manchanda *et al*., (1993) [10]. The maximum yield per plant was recorded in the plants treated with Vermicompost. Greater accumulation of dry matter conferred greater ability to produce higher yield.

Chemical parameters

The data from the investigation showed that maximum TSS (9.307 ˚ Brix), ascorbic acid (65.857 mg/ 100g) and total sugar (7.937 %) were recorded under treatment combination [(30 cm × 30 cm) + Vermicompost] S_2M_3 (T_6). While maximum anthocyanin content (47.767 mg/ 100g) was recorded with the treatment S_1M_3 [(30 cm × 15 cm) + Vermicompost] (T_3). An increase in TSS and total sugars contents with *Azotobacter*, NPK and Vermicompost application might be due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits. The maximum amount of ascorbic acid content (54.98 mg per 100 g fresh fruit weight) was recorded in the berries produced from the plants applied with Vermicompost (30 ton per ha) + *Azotobacter* (7 kg per Ha) + NPK (80:100:100). This result got the support with the findings of Tripathi *et al.,* (2015) [18] in strawberry. Potassium promotes sugar accumulation in berries and balance of N, P and K is essential for proper availability of those nutrients to strawberry plants. Ali *et al.* (2003) [2] found an increase in TSS with farm yard manure treatment. Singh *et al.* (2008) [16] reported that increasing the dose of Vermicompost from 2.5 to 10 tonne per ha not only reduced the number of days to first bloom but also enhanced TSS and sugar contents of fruit. The sugars and acid contents in fruit are considered important for fruit quality attributes in strawberries (Wozniak *et al.,* 1997) [20] (Table 1.6-1.7).

Table 1.1: Effect of spacing and organic manures on plant spread and number of leaves per plant

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	22.953	26.143	25.007	24.701	12.140	14.720	14.663	13.841
S_2	23.617	27.490	31.933	27.680	14.160	17.403	25.803	19.122
S_3	24.687	27.530	28.210	26.809	14.753	15.933	18.110	16.266
Mean M	23.752	27.054	28.383		13.684	16.019	19.526	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	0.419		0.896		0.558		1.193	
Factor (M)	0.419		0.896		0.558		1.193	
Factor (S×M)	0.726		1.552		0.967		2.067	

Table 1.2: Effect of spacing and organic manures on leaf area and number of flowers per plant

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	27.977	31.437	32.297	30.570	19.313	24.890	34.727	26.310
S_2	30.387	32.500	41.707	34.864	20.827	39.033	41.673	33.844
S_3	30.730	36.333	34.693	33.919	21.610	40.707	32.103	31.473
Mean M	29.698	33.423	36.232		20.583	34.877	36.168	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	1.363		2.915		0.258		0.552	
Factor (M)	1.363		2.915		0.258		0.552	
Factor (S×M)	2.361		5.048		0.447		0.957	

Table 1.3: Effect of spacing and organic manures on duration of flowering (days) and duration of fruiting (days)

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	37.693	40.557	42.517	40.256	42.067	49.207	55.780	49.018
S_2	39.727	43.827	47.727	43.760	48.753	57.923	62.627	56.434
S_3	38.463	46.427	41.207	42.032	41.140	59.603	51.260	50.668
Mean M	38.628	43.603	43.817		43.987	55.578	56.556	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	0.294		0.629		0.591		1.263	
Factor (M)	0.294		0.629		0.591		1.263	
Factor (S×M)	0.509		1.089		1.023		2.188	

Table 1.4: Effect of spacing and organic manures on fruit set (%)

Spacing	**Organic manures (M)**			
	M_1	**M_2**	**M_3**	**Mean S**
S_1	75.037	77.080	79.133	77.083
S_2	71.017	82.370	87.373	80.253
S_3	71.260	84.133	77.160	77.518
Mean M	72.438	81.194	81.222	
Factors	SE(d)		C.D.$_{(0.05)}$	
Factor (S)	0.364		0.778	
Factor (M)	0.364		0.778	
Factor (S×M)	0.630		1.347	

Table 1.5: Effect of spacing and organic manures on yield per plant (g) and yield per plot (kg)

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	125.150	178.333	272.303	191.929	1.880	2.673	4.087	2.880
S_2	150.587	333.530	444.293	309.470	1.807	4.000	5.330	3.712
S_3	113.330	345.240	276.480	245.017	1.020	3.107	2.490	2.206
Mean M	129.689	285.701	331.026		1.569	3.260	3.969	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	9.217		19.708		0.114		0.243	
Factor (M)	9.217		19.708		0.114		0.243	
Factor (S×M)	15.965		34.135		0.197		0.421	

Table 1.6: Effect of spacing and organic manures on total soluble solid (ºBrix) and ascorbic acid (mg/100g)

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	5.373	5.830	6.153	5.786	48.353	51.390	54.130	51.291
S_2	5.533	7.493	9.307	7.444	54.843	57.257	65.857	59.319
S_3	5.803	7.503	7.737	7.014	60.500	59.290	63.163	60.984
Mean M	5.570	6.942	7.732		54.566	55.979	61.050	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	0.339		0.724		0.422		0.902	
Factor (M)	0.339		0.724		0.422		0.902	
Factor (S×M)	0.587		1.254		0.730		1.562	

Table 1.7: Effect of spacing and organic manures on total sugar (%) and anthocyanin content (mg/ 100 g)

	Organic manures (M)							
	M_1	**M_2**	**M_3**	**Mean S**	**M_1**	**M_2**	**M_3**	**Mean S**
S_1	5.523	5.933	6.477	5.978	38.413	45.130	47.767	43.770
S_2	6.640	7.183	7.937	7.253	40.617	45.693	43.993	43.434
S_3	7.093	7.417	7.137	7.216	42.137	53.853	44.750	46.913
Mean M	6.419	6.844	7.183		40.389	48.226	45.503	
Factors	SE(d)		C.D.$_{(0.05)}$		SE(d)		C.D.$_{(0.05)}$	
Factor (S)	0.153		0.326		0.588		1.257	
Factor (M)	0.153		0.326		0.588		1.257	
Factor (S×M)	0.264		0.565		1.018		2.177	

Conclusions

On the basis of present investigation it is concluded that S_2M_3 [(30 cm × 30 cm) is best spacing as compared to other spacing taken under study for influencing the growth and yield of strawberry under mid hill conditions of Uttarakhand. As regards the organic manure the M_3 (Vermicompost) was found most suitable under study about all observations. Therefore, all treatment combinations as such significantly affect all the parameters, however S_2M_3 [(30 cm × 30 cm) + Vermicompost] (T_6) gave the most superior result.

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